

NCDOT Pavement Marking Asset Management Program





NCDOT Pavement Marking Asset Management Program Goals



- Increase safety
- Maximize value for money



NCDOT Pavement Marking Asset Management Program Goals



- Develop a statewide user friendly, “living” database
- Provide guidance to designers, engineers, and others engaged in the selection of pavement marking materials
- Selection of pavement marking materials based upon demonstrated product durability, retained retroreflectivity and cost



NCDOT Guidelines for Use of Pavement Markings (Draft last updated 7-16-01)



Purpose:

To **improve visibility during night and wet night conditions** and possibly reduce night and wet night “run off the road” accidents.

Pavement Marking **Placement Guidelines**

- Long life pavement marking (epoxy, thermoplastic and polyurea) on the National Highway System
- Epoxy markings may be used on asphalt pavement west of and including I-77
- Thermoplastic markings on asphalt pavement
- Waterborne paint markings on all non-NHS roadways with ADT less than 5000 ADT

Consideration may be given to:

- Large gradation glass beads
- Snow plow rates
- Life cycle cost



NC DOT Guidelines for Use of Pavement Markings (Draft last updated 7-16-01)



Long life pavement marking (epoxy, thermoplastic and polyurea) on the National Highway System (NHS)

- 5 Year Data Collection: 11 of 14 Divisions
- Total NHS lane miles: estimated 15,000
- Total line miles under evaluation: 2160.9

Epoxy markings may be used on asphalt west of and including I-77

- No retroreflectivity data was collected as no projects on the National Highway System were identified.



Long Life Pavement Marking



Long life pavement marking (epoxy, thermoplastic and polyurea) on the National Highway System (NHS)

*Long Life Pavement Markings by **Surface Type** for All Regions Under Evaluation*

<u>Surface</u>	<u>Material</u>	<u>Bead</u>	<u>Line Miles</u>
<i>Asphalt</i>	Thermo	Standard	1068.5
	Thermo	Large	236.1
	Hot Spray Thermo (40 mil)	Standard	310.2
	Polyurea	Highly Reflective Elements	45.0
		Sum	1659.8
<i>Concrete</i>	Epoxy	Standard	249.9
	Epoxy	Large	220.0
	Polyurea	Highly Reflective Elements	31.2
		Sum	501.1
<i>Total Line Miles</i>			2160.9



Thermoplastic Pavement Markings on Asphalt Pavement



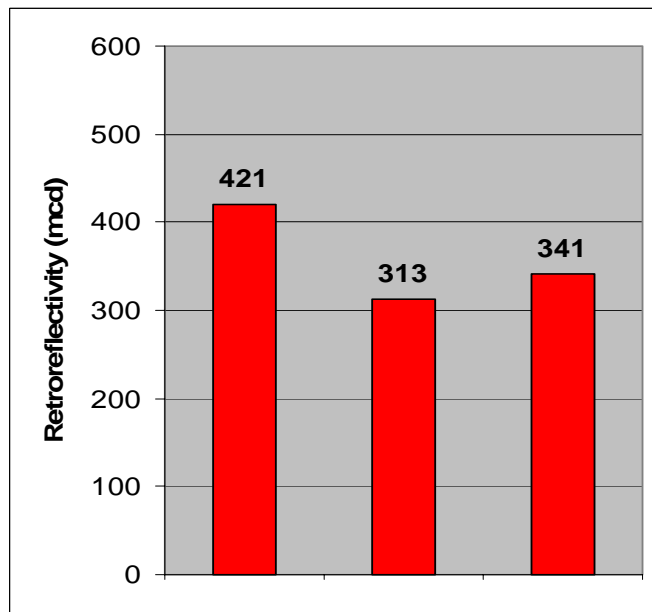
White & Yellow Thermoplastic in All Regions

- NC Standard Spec Bead 1068.5 line miles
- Large Bead 236.1 line miles

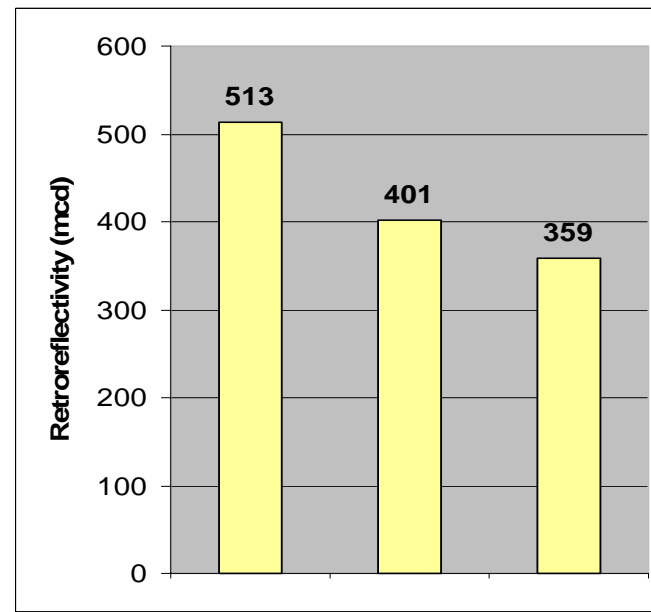
Sample: *White Skip* Thermoplastic with NC Standard Spec Bead (148.4 line miles)

Sample: *White Skip* Thermoplastic with Large Bead (32.1 line miles)

Average #
of Snow
Plows: 5



Avg. Initial R_L Avg. 6 Month R_L Avg. 1 Year R_L



Avg. Initial R_L Avg. 6 Month R_L Avg. 1 Year R_L

Average #
of Snow
Plows: 4



Waterborne Paint Markings on Asphalt Pavement

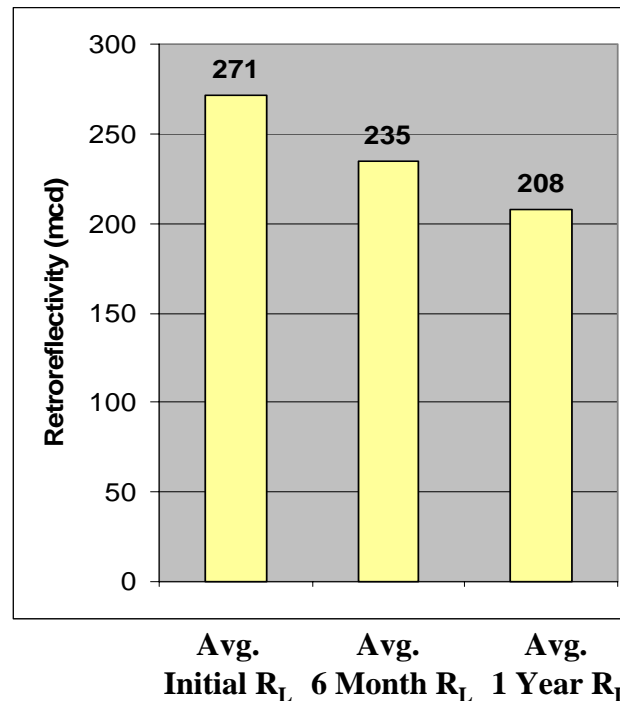


White & Yellow Paint in All Regions

- NC Standard Spec Bead 75.1 line miles

Sample: *White Edge Paint on Asphalt* (50.1 line miles)

Average #
of Snow
Plows: 4





NC DOT “Data Driven” Guidelines for Use of Pavement Markings (Possible Additions)



Establish Pavement Marking Performance Guidelines

- Initial retroreflectivity levels
- Six month retroreflectivity levels
- Life cycle cost/Brightness Benefit Factor (BBF) chart

Establish Pavement Marking Construction Guidelines

- Life cycle cost
- Brightness Benefit Factor (BBF) chart
- Asset management

Establish Pavement Marking Restriping/Maintenance Guidelines

- End of useful life
- Brightness Benefit Factor (BBF) chart
- Asset management



Retroreflectivity Performance Levels for White Pavement Markings (Possible Additions)



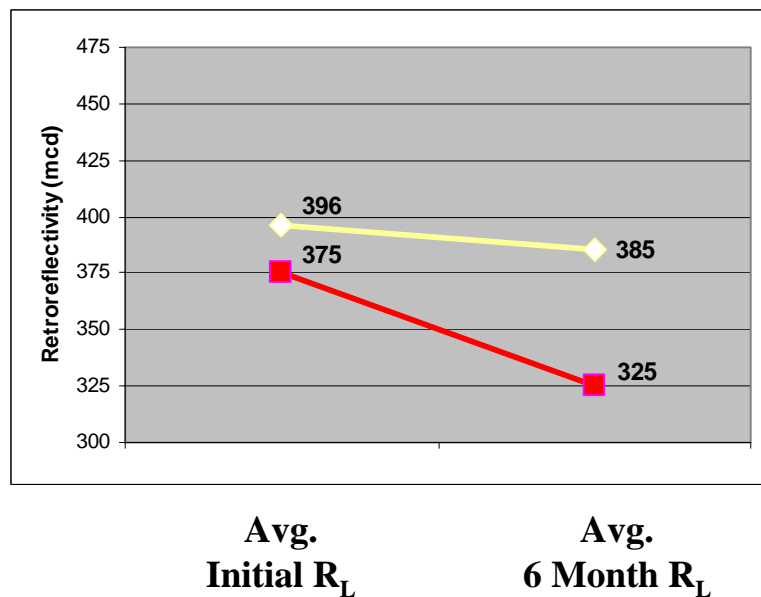
NC Standard Spec Bead Initial R_L level (**375 mcd**)

Large Bead Initial R_L level (**450 mcd**)

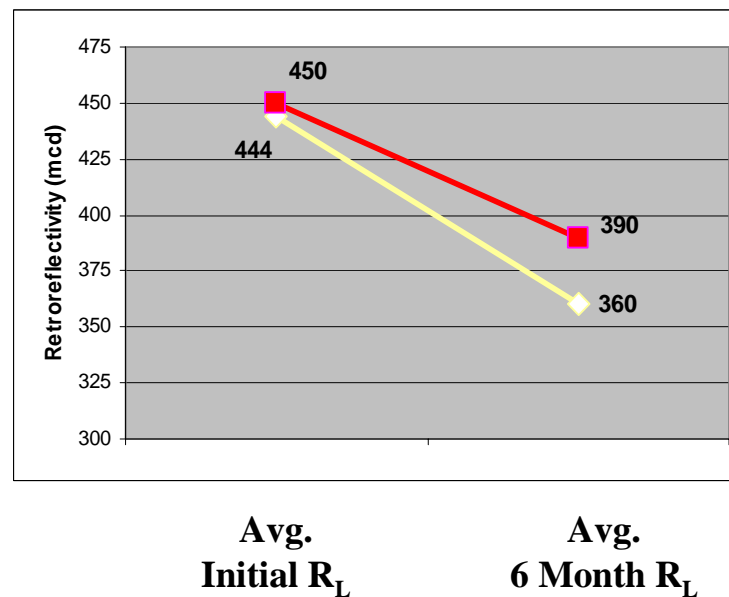
NC Standard Spec Bead Six Month R_L level (**325 mcd**)

Large Bead Six Month R_L level (**390 mcd**)

**Sample: *White Edge Thermoplastic with
NC Standard Spec Bead***
(332.1 line miles)



**Sample: *White Edge Thermoplastic with
Large Bead***
(114.0 line miles)





Retroreflectivity Performance Levels for Yellow Pavement Markings (Possible Additions)



NC Standard Spec Bead Initial R_L level (**250 mcd**)

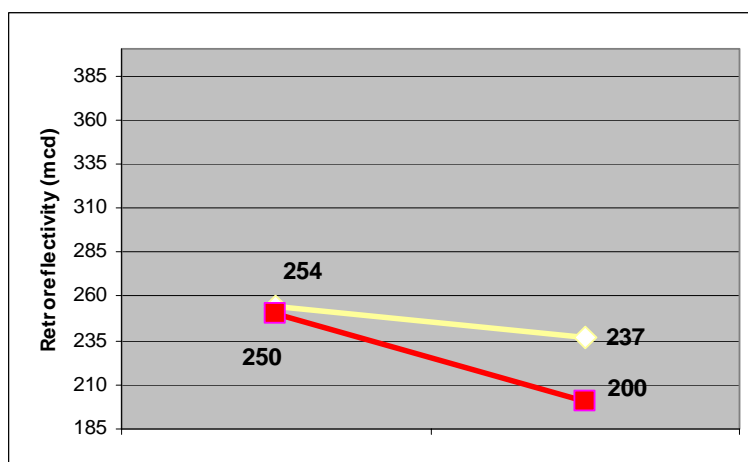
Large Bead Initial R_L level (**300 mcd**)

NC Standard Spec Bead Six Month R_L level (**200 mcd**)

Large Bead Six Month R_L level (**240 mcd**)

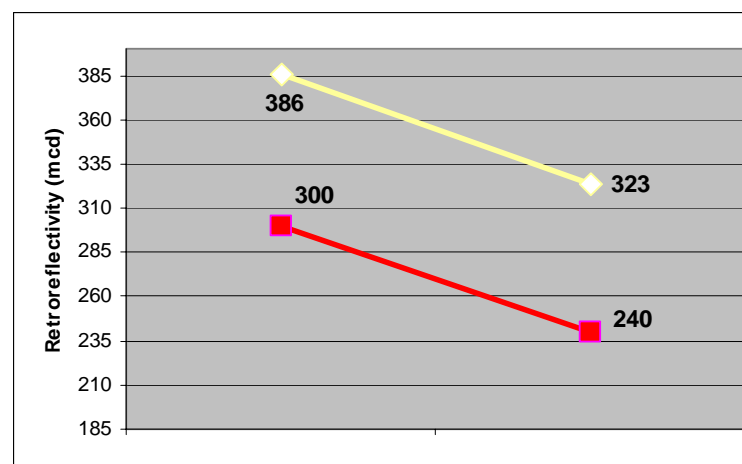
**Sample: *Yellow Edge* Thermoplastic with
NC Standard Spec Bead
(232.2 line miles)**

**Sample: *Yellow Edge* Thermoplastic with
Large Bead
(32.6 line miles)**



Avg.
Initial R_L

Avg.
6 Month R_L



Avg.
Initial R_L

Avg.
6 Month R_L



Life Cycle Cost (Possible Additions)



- Variety of ways to conduct a life cycle cost analysis
- NC DOT will establish retroreflectivity level as the end of a pavement markings useful life.
- NC DOT will have to determine how to weigh intangible costs involved in installing pavement markings i.e:
 - Frequency of striping, cost of contract administration
 - Traffic obstruction, decreased capacity
 - Work zone safety, etc.
- One possible methodology to be considered is the establishment of a “Brightness Benefit Factor” (BBF)



Brightness Benefit Factor (BBF) (Possible Additions)



- Brightness benefit factor represents the combined effects of a material's retroreflectivity, durability, and installed cost.
- Brightness benefit factor formula: $BBF = (R_u T_s) / \$$
 - R_u = Average useful retroreflectivity over the anticipated service life of the project.
 - T_s = Service life
 - $\$$ = The average installed cost per unit length (foot).
- R_u is determined from most current project experience and is calculated by taking yearly retroreflectivity readings on roadways representative of the ADT classification in which the BBF is listed.
- Bias toward products with high initial retroreflectivity. NC DOT needs to decide whether to establish maximum useful initial retroreflectivity.
- Intangible cost has not been taken into consideration in this example.



Brightness Benefit Factor (BBF)

(Possible Additions)



$$\text{BBF} = (R_u T_s) / \$$$

Sample BBF calculation:

- ADT = >25,000
- Cost per foot = \$ 0.55
- Useful life for white 150 mcd
- 513 mcd Installation
- 352 mcd At end of 1st year
- 243 mcd At end of 2nd year
- 168 mcd At end of 3rd year
- 116 mcd At end of 4th year
- Sum R = (513+352)/2 + (352+243)/2 + (243+168)/2 + (168+116)/2 = 1078 mcd
- R average = 1078/4 = 269 mcd
- R_u , the average useful retroreflectivity, is the amount by which the average retroreflectivity exceeds 150 mcd for white
 - $R_u = 269 - 150 = 119$ mcd
 - $T_s = 4$ years
 - \$ = \$ 0.55
 - $\text{BBF} = (R_u T_s) / \$ = (119)(4) / (0.55) = 865$



Brightness Benefit Factor (BBF) (Possible Additions)



Average Retroreflectivity for 5 Years for BBF Calculation

Cost/ Foot	Materials	Surface	Bead	ADT Range	Line	1 Year % Drop	Initial	1 Year	2 Year	3 Year	4 Year	5 Year	Incipient Failure
0.37	Epoxy	Concrete	Standard	>25,000	WE	19%	340	275	223	180	146	-	150
					WS	-	-	-	-	-	-	-	150
					YE	0%	210	210	-	-	-	-	100
0.49	Epoxy	Concrete	Standard	>25,000	WE	15%	343	292	248	211	179	152	150
					WS	18%	284	234	192	157	129	-	150

Cost/ Foot	Materials	Surface	Bead	ADT Range	Line	1 Year % Drop	Initial	1 Year	2 Year	3 Year	4 Year	5 Year	Incipient Failure
0.55	Thermo	Asphalt	Large	>25,000	WS	31%	513	352	243	168	116	-	150

					YE	10%	331	297	267	241	217	195	100
0.3	Thermo	Asphalt	Standard	10,000-25,000	WE	6%	346	325	306	287	270	254	150
					YE		317	354	-	-	-	-	100
0.36	Thermo	Asphalt	Standard	10,000-25,000	WS	25%	467	350	263	197	148	-	150
0.37	Thermo	Asphalt	Standard	10,000-25,000	WE		390	439	-	-	-	-	150
					YE		279	327	-	-	-	-	100
0.83	Thermo	Asphalt	Standard	>25,000	WE	16%	441	370	311	261	219	184	150

- Assumption percentage drop same every year.
- Assume no more than 5 years.



Brightness Benefit Factor (BBF) (Possible Additions)



BBF Calculation for 5 Years

$$BBF = (R_u T_s) / \$$$

Material	Surface	Bead	ADT Range	Line	Initial	1 Year	2 Year	3 Year	4 Year	5 Year	Sum	R Average	R ₀	Incipient Failure	Cost per Foot	mcd-years per dollar-foot (BBF)	Cost per Mile	Years		
Epoxy	Concrete	Standard	>25,000	WE	308	249	202	163	-	-	921	230	80	150	5	0.37	868	\$1,954	4	
				WS	-	-	-	-	-	-	-	-	-	-	150	5	0.37	-	-	-
				VE	210	-	-	-	-	-	-	-	-	-	100	5	0.37	-	-	-
Epoxy	Concrete	Standard	>25,000	WE	318	270	230	195	166	1178	236	86	150	5	0.49	872	\$2,587	5		
				WS	259	213	176	143	-	780	157	47	150	5	0.49	387	\$2,587	4		
				VE	208	181	157	137	119	801	160	80	100	5	0.49	614	\$2,587	5		
Epoxy	Concrete	Large	>25,000	WE	333	246	182	135	-	896	224	74	150	5	0.44	673	\$2,323	4		
				WS	-	-	-	-	-	-	-	-	-	-	150	5	0.44	-	-	-
				VE	294	186	118	-	-	598	159	90	100	5	0.44	676	\$2,323	3		

Retroreflectivity
over lifetime

Material	Surface	Bead	ADT Range	Line	Initial/1 Year	1 Year/2 Year	2 Year/3 Year	3 Year/4 Year	4 Year/5 Year	Sum R	R Average	R_u	Incipient Failure	Cost/ Foot	mcd-years per dollar-foot (BBF)	Cost/ Mile
Thermo	Asphalt	Large	>25,000	WS	433	298	206	142	-	1078	269	119	150	\$0.55	865	\$2,904

Thermo	Asphalt	Standard	>25,000	WE	308	249	202	163	-	921	230	80	150	5 0.32	2192	\$1,890	5
				VE	189	155	127	104	-	574	143	43	100	5 0.32	642	\$1,890	4
Thermo	Asphalt	Large	<10,000	WE	351	247	173	-	-	770	257	107	150	5 0.29	1103	\$1,531	3
Thermo	Asphalt	Large	<10,000	VC	292	245	206	173	145	1060	212	112	100	5 0.32	1750	\$1,890	5
Thermo	Asphalt	Large	10,000-25,000	VC	254	206	167	135	110	870	174	74	100	5 0.32	1156	\$1,890	5
Thermo	Asphalt	Large	10,000-25,000	WE	409	318	248	183	151	1317	263	113	150	5 0.29	1955	\$1,531	5
Thermo	Asphalt	Large	>25,000	WE	440	336	255	194	147	1371	274	124	150	5 0.53	1172	\$2,798	5
				VE	333	242	177	129	95	975	195	95	100	5 0.53	896	\$2,798	5
Thermo	Asphalt	Large	>25,000	WS	433	298	206	142	-	1078	269	119	150	5 0.55	865	\$2,904	4
Polyurea	Asphalt	3M	10,000-25,000	WE	833	589	374	251	168	2184	437	207	150	5 0.85	1686	\$4,488	5
				WS	880	706	565	452	361	2963	593	443	150	5 0.85	2603	\$4,488	5
				VC	476	315	208	137	91	1225	245	145	100	5 0.85	863	\$4,488	5
				VE	901	802	713	635	565	3615	723	623	100	5 0.85	3665	\$4,488	5
Paint	Asphalt	Standard	<10,000	WE	221	-	-	-	-	221	221	71	150	5 0.08	881	\$422	1
				VC	199	-	-	-	-	199	199	99	100	5 0.08	1238	\$422	1
Paint	Concrete	Standard	10,000-25,000	WE	172	-	-	-	-	172	172	22	150	5 0.08	289	\$422	1
				WS	186	139	-	-	-	325	163	13	150	5 0.08	313	\$422	2
				VE	204	150	158	139	123	630	161	41	100	5 0.08	3748	\$422	2

- Assumption percentage drop same every year.
- Assume no more than 5 years.



Average Brightness Benefit Factor for White Pavement Markings with ADT>25,000 (Possible Additions)



White Edge/Asphalt			
Material	Surface	Bead	BBF
Thermo	Asphalt	Standard	1532
Thermo	Asphalt	Large	1172
Hot Spray Thermo	Asphalt	Standard	XXX

White Skip/Asphalt			
Material	Surface	Bead	BBF
Thermo	Asphalt	Large	865
Thermo	Asphalt	Standard	XXX
Hot Spray Thermo	Asphalt	Standard	XXX

White Edge/Concrete			
Material	Surface	Bead	BBF
Epoxy	Concrete	Large	673
Paint	Concrete	Standard	256

White Skip/Concrete			
Material	Surface	Bead	BBF
Epoxy	Concrete	Large	427
Epoxy	Concrete	Standard	387

XXX: Precision Scan will have information after June 2003 measurements are taken.

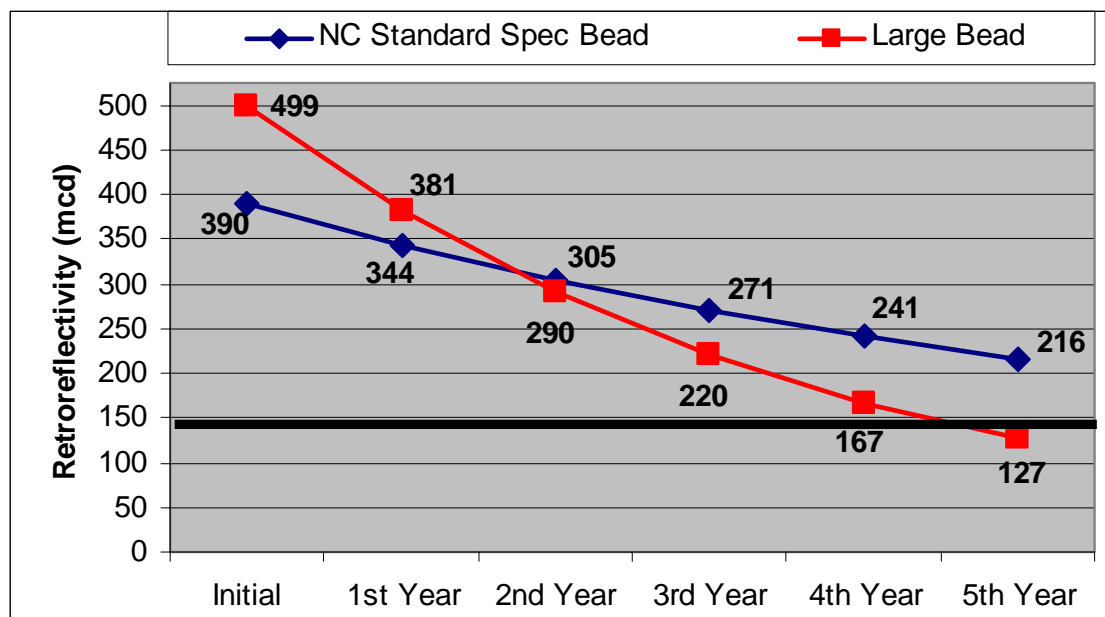


Restriping/Maintenance Guidelines (Possible Additions)



Base restriping/maintenance on data driven decisions

Sample: *White Edge* Thermoplastic with
NC Standard Spec Bead and **Large Bead** on Asphalt
with ADT >25,000



BBF Chart (ADT >25,000)

White Edge/Asphalt			
Material	Surface	Bead	BBF
Thermo	Asphalt	Standard	1532
Thermo	Asphalt	Large	1172
Hot Spray Thermo	Asphalt	Standard	XXX

- Assumption percentage drop same every year.
- Assume end of useful life is 150 mcd



There's Still Work to Be Done...



Central Office

- Establish database
- Establish performance guidelines
- Establish placement/construction/restriping guidelines based on life cycle cost/Brightness Benefit Factor (BBF)
- Annual review of guidelines

Divisions

- Inspection: Retroreflectivity collection and reporting
 - Get what you pay for
 - Maintain database
- Contractor: Monitoring (Incentives)
- Construction/Restriping/Material Selection: Brightness Benefit Factor (BBF)

Sample: General Contractor Performance

Report to Print

- ☐ All Contractors
- ☒

Select Single Contractor

Print Preview

Print

Close

To print the directory page for only one Contractor, select the Contractor name from the list below

Contractor

Boggs Paving, Inc.
Clark Pavement Marking, Inc.
Denville Line Painting, Inc.
Highway Valets, Inc.
Ledbetters Pavement Marking
Olgesby Construction, Inc.
Peek Pavement Marking, Inc.



User Friendly Database Reports



Sample: Contractor /Material Performance

Contractor Report by Individual Contractor								
Contractor	Line	Surface	Material	Beads	Avg of Initial RL Readings	Avg of 6 Month RL Readings	Avg of 1 st Year RL Readings	Avg Cost Per Foot
Clark Pavement Marking, Inc.								
White Edge								
		Asphalt	Hot Spray Thermo	Standard	0	246	317	\$0.19
		Asphalt	Thermo	Standard	408	368	424	\$0.33
White Skip								
		Asphalt	Hot Spray Thermo	Standard	0	260	358	\$0.19
		Asphalt	Thermo	Standard	234	381	402	\$0.41
Yellow Edge								
		Asphalt	Hot Spray Thermo	Standard	0	192	221	\$0.19
		Asphalt	Thermo	Standard	305	263	312	\$0.33



User Friendly Database



Sample: Contractor/Material Performance at Division Level

Report to Print

☐ All Division

☒

Select Single Division

Print Preview

Print

Close

To print the directory page for only one Division, select the Division # from the list below

Division

1

2

3

4

5

6

7

8



User Friendly Database Reports



Sample: Report Selection by Division

Contractor Summary Report by Division								
Note: Measurements were NOT taken if there is a zero (0) in the RL Average column.								
Contractor	Line	Surface	Material	Beads	Avg of Initial RL Readings	Avg of 6 Month RL Readings	Avg of 1 st Year RL Readings	Avg Cost Per Foot
Division: 7								
Clark Pavement Marking, Inc.								
	White Edge	Asphalt	Thermo	Standard	427	364	410	\$0.28
	White Skip	Asphalt	Thermo	Standard	467	360	350	\$0.36
	Yellow Edge	Asphalt	Thermo	Standard	331	236	297	\$0.28
Roadmark Corporation								
	White Edge	Asphalt	Paint	Standard	271	235	208	\$0.08
		Concrete	Paint	Standard	204	172	139	\$0.08
	White Skip	Concrete	Paint	Standard	200	189	148	\$0.08
	Yellow Center	Asphalt	Paint	Standard	170	172	190	\$0.08
	Yellow Edge	Concrete	Paint	Standard	198	175	171	\$0.08



User Friendly Database



Sample: Report Selection

Division	Type of Line	Color	Surface Material	Material Type	ADT	Beads	Contractor	Cost
<input type="radio"/> Division 1	<input type="radio"/> Division 5	<input type="radio"/> Division 9	<input type="radio"/> Division 13					
<input type="radio"/> Division 2	<input type="radio"/> Division 6	<input type="radio"/> Division 10	<input type="radio"/> Division 14					
<input type="radio"/> Division 3	<input checked="" type="radio"/> Division 7	<input type="radio"/> Division 11						
<input type="radio"/> Division 4	<input type="radio"/> Division 8	<input type="radio"/> Division 12						

	Division	Type of Line	Color	Surface Material	Material Type	ADT	Beads	Contractor
	7	White Skip	White	Asphalt	Thermo	20,000	Standard	Clark Pavement Marking, Inc.
	7	Yellow Edge	Yellow	Asphalt	Thermo	20,000	Standard	Clark Pavement Marking, Inc.
	7	White Edge	White	Asphalt	Thermo	20,000	Standard	Clark Pavement Marking, Inc.
	7	White Skip	White	Asphalt	Thermo	20,000	Standard	Clark Pavement Marking, Inc.
	7	Yellow Edge	Yellow	Asphalt	Thermo	20,000	Standard	Clark Pavement Marking, Inc.
	7	White Edge	White	Concrete	Paint	20,000	Standard	Roadmark Corporation
	7	White Skip	White	Concrete	Paint	20,000	Standard	Roadmark Corporation
	7	White Skip	White	Concrete	Paint	20,000	Standard	Roadmark Corporation
	7	Yellow Edge	Yellow	Concrete	Paint	20,000	Standard	Roadmark Corporation
	7	White Edge	White	Concrete	Paint	20,000	Standard	Roadmark Corporation

Record: ◀ ▶ 1 ▶ ▶▶ * of 220



Cost of Asset Management



Installed Material Weighted Avg. Cost/ft.:	<u>White Edge</u>	<u>White Skip</u>	<u>Yellow Center</u>	<u>Yellow Edge</u>
• Polyurea (Highly Reflective Elements):	\$0.85	\$0.85	\$0.85	\$0.85
• Epoxy (Large Bead):	\$0.44	\$0.55	N/A	\$0.44
• Epoxy (NC Std Spec Bead):	\$0.40	\$0.42	N/A	\$0.40
• Thermo (Large Bead):	\$0.33	\$0.43	\$0.32	\$0.39
• Thermo (NC Std Spec Bead):	\$0.35	\$0.39	\$0.31	\$0.32
• Hot Spray Thermo (NC Std Spec Bead):	\$0.19	\$0.19	N/A	\$0.19
• Paint (NC Std Spec Bead):	\$0.08	\$0.08	\$0.08	\$0.08
• Asset management cost /ft.: \$ 0.007				



Data Collection Questions



Currently Precision Scan collects retroreflectivity data on 2160.9 line miles over 5 years on the National Highway System

- A.** Should it be expanded to collect more specific product data (epoxy on asphalt with NC standard specification beads and/or large beads, thermoplastic ribbon and extruded, other types of roadways (non-NHS), etc.)
- B.** Should paint be measured on the non-NHS with ADT <5000 to evaluate restriping policies
- C.** Should “wet” measurements be taken for product evaluations
- D.** Should initial and 6 month performance and compliance data collection be combined with the current data collection, i.e, a percentage of pavement markings selected at random to be measured by mobile retroreflectivity in addition to handheld measurements
- E.** Should initial and six month mobile retroreflectivity measurements be taken for the divisions on non-NHS roadways

Develop material selection methodology (life cycle cost/BBF):

- Decide key “selection” factors, i.e., product durability, retained retroreflectivity, cost, intangible cost factors, etc.
- Define end of “useful life” retroreflectivity
- Define what factors are part of cost, i.e., removal, grinding, etc.
- Define ADT selection categories
- Develop plan to maintain system with annual data collection and analysis
- Decide whether wet pavement markings should be introduced
- If wet measurements are taken, need to define “acceptable” retroreflectivity levels (initial and maintained)



Database Usage



- Decide on flexible, user friendly format
- Define who has access to what
- Database maintenance plan
- Integration of data into NCDOT official guidelines



NCDOT Pavement Marking Asset Management Program Results



- Increase safety
- Maximize value for money



NCDOT Pavement Marking Asset Management Program Contacts



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